CMFRI Booklet Series No. 17/2019

Hand Book on Sea Cage Farming of Cobia

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Tamil Nadu, India

2019

CMFRI Booklet Series No. 17/2019

Published by

Dr. A. Gopalakrishnan

Director

ICAR-Central Marine Fisheries Research Institute

Kochi – 682 018

Typeseted by

Rehana Offset Printers, Srivilliputtur.

Cell : 9842175376, E-mail : rehanaoffset@gmail.com

INTRODUCTION

Aquaculture is the fastest growing animal food producing sector in the world. From an output of less than 1 million tonnes per year in the 1950's, aquaculture now produces almost 100 million tonnes per year. Globally, fish today provides more than 4.5 billion people with almost 15- 20% of their average per capita intake of animal protein. On an average, a person consumes 18 kilograms of fish products per year. With a growing global population and health awareness the per capita consumption of fish and fisheries products are expected to grow further. The farming of fish can help in meeting the protein requirements of the expanding population and will also provide alternate livelihood opportunities for the fisher folk and will aid their socio-economic upliftment.

Mariculture can be defined as the controlled cultivation and harvest of marine organisms, including finfish, shellfish and aquatic plants. Mariculture operations are conducted at both land and water facilities. Land-based mariculture systems include ponds, tanks, raceways, and water flow-through and recirculating systems. Water-based mariculture systems include net pens, cages, long line culture, and bottom culture. Mariculture can provide a number of socio-economic benefits, including provision of food, improved nutrition and health, generation of income and employment, diversification of primary products and increased trade earnings through the export of high-value products.

What is Cage farming?

Commercially important marine fishes can be cultured in any of the four culture systems like ponds, raceways, recirculation systems or cages. In recent years, cage culture has emerged as the most viable method of sea farming. In the simplest terms, a cage is an enclosure in the water body where the juveniles of aquatic animals are kept, fed and grown to a marketable size. Cage culture uses existing water resources (ponds, rivers, estuaries, open ocean, etc.) but confines the fish inside some type of mesh enclosure. The mesh enclosure retains the fish, making it easier to feed, observe and harvest them. The mesh also allows the water to pass freely between the fish and surrounding water, thus maintaining good water quality by removing wastes.

Cage culture probably originated with fishermen who used cages to accumulate fish for market. Over a period of time, they learned to feed the fish in these cages to increase their size and improve their overall health. The first cages used for just holding fish were probably developed in Southeast Asia at the end of the 18th century. These cages were constructed of wood or bamboo and the confined fish were fed trash fish and food scraps. Modern cage culture in the U.S. began in the 1950s with the advent of synthetic materials suitable for cage construction. There has been little research on marine cage systems because of regulatory issues, limited number of suitable sites and high cost of research. In freshwater sector, cage culture allows farmers to use existing water resources that may or may not be used for other purposes. The fish produced are usually sold to local niche markets. As wild-capture fisheries have declined and aquaculture has expanded, these niche markets have also grown. As a result, inorder to cater to the demand, more entrepreneurial opportunities developed for cage farming. The cage culture was initiated in Norway during 70s and developed into an organised industry, particularly for salmon farming. Similarly the cage culture has spread in South East Asian countries for culture of a variety of fishes. The major advantage in these countries is that they have large, calm and protected bays to accommodate the cages safely against bad weather conditions.

Annexure 1 - Continued...

Viral disease Viral Nervous Necrosis (VNN)	**Cause:** *Betanodavirus*	Fingerlings	Abnormal swimming behaviour, change in skin pigmentation	Darkening of the skin, Erythema on the skin. Brain -vacuolation ("holes" or "swiss cheese") appearance in histological sections	No treatment. Avoid from any kind of stress to the fish. Procuring and culturing specific pathogen free (SPF) seeds from the certified hatchery Prophylactic supplements of immunostimulands and probiotics.
Parasitic disease Caligus infestation	Copepode parasite- *Parapetalus occidentalis* Wilson, 1908	Grow-out, & Brood stock	Off feed surfacing, Rubbing, darkened body colour, extensive abrasions on the body surface and altered swimming behaviour.	• Pointed piercing wound in the skin • Corneal opacity • Myositis and necrosis	Formalin dip 200ppm for 5-15 min daily or until the parasite control. Fresh water dipping, Reverse osmosis (RO) water dipping (2-5min). Immersion for 5-10 mins in irritants like Euginol, Formalin (200ppm), Hydrogen Peroxide (3%) and Potassium Permanganate facilitates detachment

Annexure 1

COMMON DISEASES OF COBIA (*Rachycentron canadum*) CULTURED IN CAGE SYSTEM

Diseases / disorder	Causative agent	Stage affected	Clinical signs	Gross lesions	Treatment & prevention
Bacterial diseases 1)Vibriosis	*Vibrio alginolyticus, V. parahaemolyticus V. harvei*	Fingerlings, Grow-out, & Brood stock	Off feed surfacing, aimless erratic movement Corneal opacity Redness on the skin surface.	♦ Pin point haemorrhages/ redness ♦ Haemorrhagic gastroenteritis ♦ Ascites ♦ Haemorrhagic myocarditis ♦ Haemorrhagic septicaemia	Oxytetracyclin-10mg/kg biomass (USFDA approved drug. With drawl period 60days before harvest) Dip treatment in fresh water for 5 min
2)Enterobacteraeciae	*Enterobacter hormochii*	Fingerlings, Grow-out, & Brood stock	Off feed surfacing, sudden death	Haemorrhagic gastro enteritis	Feed supplement with probiotics and Immunostimulant in fingerlings stage
3)Photobacteriosis, or pseudotuberculosis	*Photobacterium damselae* ssp. *Piscicida*	Fingerlings, Grow-out, & Brood stock	Loss of appetite Surfacing, abdominal swelling and Acute mortality	Abdominal cavity filled with yellow gelatinous fluidLiver and kidney haemorrhagic	Prophylactic supplements of immunostimulands and vaccination by multivalent bacterial vaccine.

Advantages of Cage farming

1. Effective use of Resources

Cage culture can be established in any suitable body of water, including open seas, backwaters, lagoons or river mouths with proper water quality, seed, feeding strategies, access and permission from local authorities. This flexibility makes it possible to exploit underused water resources to produce fish.

2. Low investment

The investment for pond construction and its associated infrastructure (electricity, roads, water wells, etc.) are much higher than the cage farming, which is practiced in an existing water body and can be less expensive. At low densities (when compared to pond water spread area) cages placed in open seas, backwater and lagoons do not require aeration. Cage materials are not much expensive and can be mended with little experience.

3. Simple farming operations

In cage farming, observation of the growth and health status of the fish is easy and simple. The observation of fish behaviour, especially feeding behaviour, is critical in avoiding problems related to stress and disease outbreak.

4. Easy harvesting methods

Cages are usually harvested by moving them into shallow water, crowding the fish into a corner of the net. Otherwise, the cage net can be lifted partially out of the water so that the fish are crowded into a smaller volume, and then it can be harvested. This makes it possible to partially harvest fish from cages as and when needed for local markets.

5. **Multi-use of water resources**

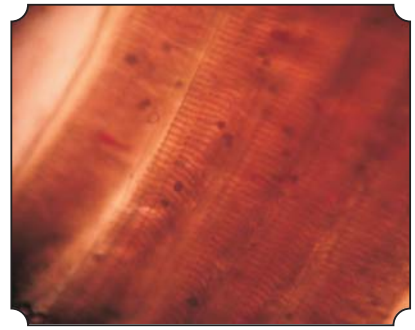
The confinement of fish in cages will not affect other uses of the water resource, such as fishing, boating, swimming, irrigation or livestock watering. Cage farming requires low capital investment and the farmer can expand production with additional cages or intensify production by increasing the stocking density at an optimal level.

SEA CAGE FARMING TECHNOLOGY IN INDIA

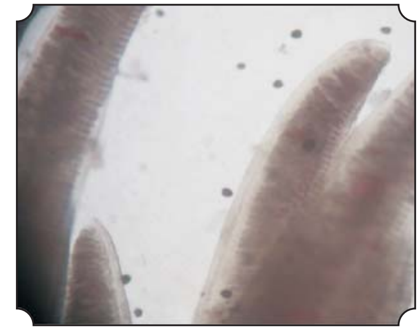
I. Cage farming techniques developed by CMFRI

India is a late starter in open sea cage farming. Research success in seed production and cage farming technology of Cobia (*Rachycentron canadum*) and Silver Pompano (*Trachinotus blochii*) was achieved for first time in India by the Central Marine Fisheries Research Institute (CMFRI). Later the farming protocols in the High Density Polyethylene (HDPE) cages and Galvanized Iron (GI) cages with different feeding strategies were developed, tested and validated. From these farming trials an economically viable farming method has been evolved. Cage farming of Cobia, Silver Pompano, Asian seabass, Milk fish (*Chanos chanos*) and fattening of lobsters were undertaken by the fishermen groups and farmers with the technology support of regional and research centres of CMFRI located in the maritime states of the country.

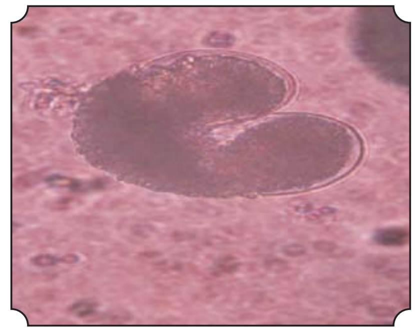
While promoting open sea cage farming, it is essential to provide necessary technical inputs to the fishermen and farmers to understand and adopt cage farming protocols to minimize the risk and maximize the production. Based on the current open sea cage farming practices in the country, economically viable & successful farming practices were documented by the CMFRI. These farming practices are made into a set of guidelines for open sea cage farming in the present manual.



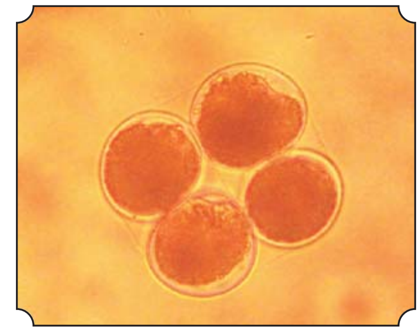
Wet mount Gill-Infested with feeding stage of trophonts



Gill; Individual trophonts with severe infestation



Reproductive stage: Tomont



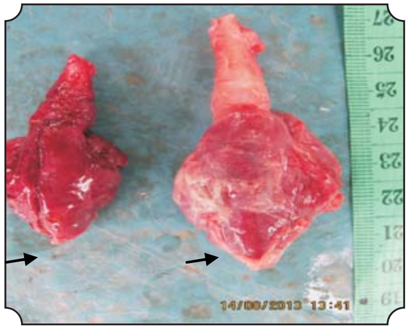
Reproductive stage: Tomont

Further Reading :

- BAP Finfish and Crustacean Farm Standards (2015). Guidelines Finfish and Crustacean Farms- Best Aquaculture Practices, Certification Standards, Aquaculture Facility Certification by Global Aquaculture Alliance.
- *Good Aquaculture Practices Series* (2009). Aquaculture Fisheries Division, Agriculture, Fisheries and Conservation Department, Government of Hong Kong.
- Guidelines on ASEAN Good Aquaculture Practices (ASEAN GAqP) for Food Fish (2015). ASEAN Secretariat, Jakarta, Indonesia.
- Reza, S. P., Abdullah and Kurnia, N. Practical Manual on better management practices for Grouper Culture in Indonesia.

Common Diseases of Cobia

Vibriosis: Distended abdomen with white to serosanguinous fluid



Vibriosis: Heart-haemorrhagic and fibrinous pericarditis

VNN - Brain Congestion

VNN - Liver severe congestion at caudal lobe

Parapetalus occidentalis Wilson, 1908: Female and male

Parapetalus occidentalis Wilson, 1908: Female with genital core

II. Site selection :

Selection of suitable site for sea cage farming is essential for smooth and easy farming operations. A healthy seabed having sandy soil is necessary in keeping satisfactory water quality. Cage farming produce organic waste like residual fish feed, fish waste and fish carcasses. Under normal conditions, these waste materials are consumed by wild fishes, crabs, sand dwelling organisms or flushed through the water current. Cages have to be moored at appropriate depth having enough space between the net bottom and sea floor (minimum 2 – 3 meters), so as to allow the waste materials to move from the cage farming area through water currents. When a cage is moored in low depth area with poor planning such as over density, over feeding or improper disposal of dead fish will increase load of organic matter in the water body and will cause problems like turbidity, anoxia, death of benthic species and increase in bacterial growth. If the cage net depth is 3.5 meters the depth of the cage farming site should be minimum 6 meters during low tide. Dissolved oxygen level is comparatively lower at the sea floor and fishes cultured too close to the sea bed may suffer from anoxia.

Basic practices to be followed during cage farming are:-

- Proper acclimatization of fish fingerlings prior to stocking
- Maintaining appropriate stocking density in the cages
- Removal of fouling organisms from the cage net or frequent changing of fouled nets.
- Good feeding and feed management
- Regular prophylactic treatments to maintain good health of the fishes
- Proper disposal of dead fishes from the cages
- Maintenance of farming records
- Cage farms shall comply with state and national labour laws

with regard to permissions for cage culture, labour deployment worker safety and on-site living conditions.

III. Species selection

Cage culture in open seas requires a fish variety with the basic characters like, commercial importance, consumer acceptance, easy to culture, adaptability to the cage environment, acceptance of artificial diets, faster growth rate and resistance to common diseases. A variety of commercially important marine fishes including, Cobia (*Rachycentron canadum*), Seabass (*Lates calcarifer*), Snappers (*Lutjanus* sp.), Carangids (*Trachinotus* sp.) and Groupers (*Epinephelus* sp.) are highly suitable for cage farming. Commercial level seed production technology for majority of these fishes has been developed in many of the South East Asian countries.

IV. Stocking density

As fishes grow, they need more space for movement; whereas, the space in net cage is limited. Hence it is necessary to stock optimal quantity of fishes according to size or weight of fish fingerlings. Since the space in a net cage is limited, it is necessary to make adjustment according to the size or weight of fish stock. Failure to observe this will weaken the immunity of fish and result in higher risk of injury caused by fish knocking against each other as well as bacterial, viral or parasitic infection. Another risk associated with high stocking density is that dissolved oxygen may be insufficient to sustain the entire stock. This is particularly common when water level is too low and water current is poor or water is stagnant. The fish stock may suffer from anoxia. Moreover, fish waste may also encourage growth of bacteria. Overstocking will weaken the fish resulting in higher risk of bacterial, viral or parasitic infection. Higher stocking densities also leads to insufficient level of dissolved oxygen to sustain the entire stock. During low tide and poor water current, unavailability of required level of dissolved oxygen leads to anoxia and death. A 6 meter dia cage having net depth of 3.5

Cage farming of Cobia (*Rachycentron canadum*)

HDPE Cage (6 meter Dia)

GI Pipe Cage (6 meter Dia)

Cobia fingerlings (60 days old)

Cobia juveniles (While feeding)

Cobia Juveniles (3.5 Kg size)

Harvested Cobia

The growth details of cobia as recorded in sea cages at a stocking density of 8 fishes/m^3 are provided below for reference:

Growth details of Cage Farmed Cobia

Duration	Length (cm)	Weight (g)	Duration	Length (cm)	Weight (g)
Month-0	17.1 ± 0.2	37.9 ± 1.3	Month-7	73.5 ± 1.0	3316.2±57.6
Month–1	21.5 ± 0.3	70.8 ± 2.4	Month–8	77.9 ± 1.1	4015.4±74.0
Month–2	22.4 ± 0.6	94.1 ± 1.3	Month–9	85.7 ± 0.9	4851.1±88.8
Month–3	26.0 ± 0.8	125.3 ± 2.5	Month–10	90.8 ± 1.2	5622.4±146.5
Month–4	32.9 ± 1.1	468.5 ± 27.8	Month–11	96.6 ± 1.6	6291.8±138.9
Month–5	46.3 ± 1.0	1109.3±87.7	Month–12	103.0 ± 1.7	7276.6±148.6
Month–6	56.4 ± 1.1	1985.5±92.3			

meters, can be stocked with 750 numbers of cobia fingerlings or 4,000 numbers of silver pompano or 2500 numbers of Asian seabass fingerlings.

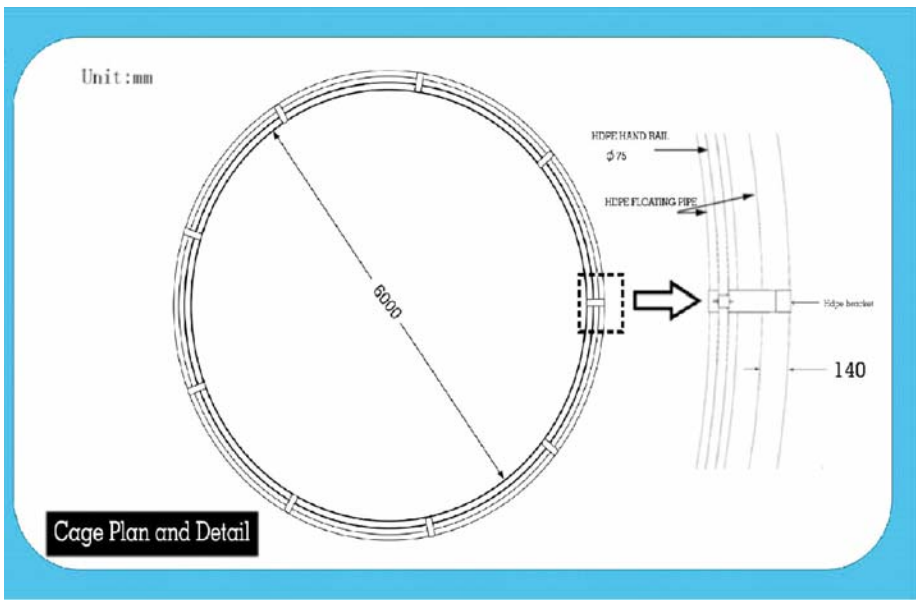
V. Transportation, acclimatization and stocking of fish fingerlings

Transportation of fish fingerlings at optimal density and water quality parameters plays a vital role in reducing stress and improving the survival. Generally, fish fingerlings are starved for a minimum of 24 hours prior to transport to avoid excretion of faecal materials during transport. This would greatly help in maintaining the water quality during transport. Further, transportation of fish in low temperatures (reducing temperature to 22 – 24°C) would help to minimize the basic metabolic rate of the fish and thereby help in maintaining the optimal water quality during transport. While packing the fish fingerings in polythene bags the optimal level of oxygen has to be maintained by filling with medical grade oxygen. Ideal quantity of cobia fingerlings for transport for 24hrs period has been evaluated as 125 grams of biomass in 9-10 litres of water in the polythene bags filled with thrice the volume of medical grade oxygen. Ammonia levels will normally increase during transport and it can be reduced by adding appropriate management chemicals in the packing water.

Fish fingerlings procured from the hatchery or wild needs to be acclimatized to new environment to get better survival and growth. Fish fingerlings brought from the hatchery or wild have to be acclimatized in tanks/pens/ nursery cages for a short period to observe their health conditions. If abnormal behaviour or infection symptoms are noticed, such fingerlings have to be isolated and reared separately. To avoid spread of diseases, fish fingerlings infected with pathogens should be given proper treatment. Approved disinfectants/antibiotics can be used for treating the diseases in consultation with the fisheries officials/ CMFRI scientists. Excessive use of disinfectants or therapeutic drugs will lead to problems like increasing organic matter in the water, excessive fish drug residues, drug resistance in bacteria and wastage. It has adverse impacts on both environment and health of fish.

VI. Cage design and fabrication

For sea cage farming of marine finfishes it is always better to use circular type cages which are sturdy enough to withstand rough weather, high waves, turbulence, heavy wind and water current. Sea cages are normally manufactured with Galvanized Iron or High Density Poly Ethylene (HDPE) material to withstand the rough conditions. Cages are preferably made as circular or rectangular in shape. While using Galvanized Iron material, if the cages are made in circular shape it can with stand the rough conditions better than the rectangular or square shapes.



Top View of a Circular Cage

Grow-out Phase

The grow-out culture has to be carried out in circular floating sea cages of 6 meter diameter. The cage frames should be made up of HDPE pipes or GI pipes. The handrail has to be fixed at half meter height from the base. The space between inner and outer rings of the cage has to be kept as one meter. The net cages fabricated with HDPE ropes of 2.5 mm thickness and the mesh size of 40 mm for inner net cage and 60 mm for outer net cage has to be used. The depth of the net cages should be maintained at 4.0 meters from the base. The shape of the net cages can be maintained with circular ballast. The cages were floated and moored as mentioned in Nursery Phase 2.

The juveniles from nursery phase 2 have to be transferred to these grow-out sea cages. The stocking density at this phase has to be maintained at 3.0-5.0 kg/m^3 or 750 no.s of juvenile cobia per cage. The juveniles can be fed @ 5% total biomass of fish with chopped low-value fishes (sardine, lesser sardine, rainbow sardine, etc.) once daily. Net cages have to be changed based on the subjective assessment of fouling of the net in order to have sufficient water exchange. Random sampling has to be carried out at monthly intervals with the sample size of 30 nos. per cage. The entire grow-out culture can be carried out for a period of 6- 7 months.

Growth Performance

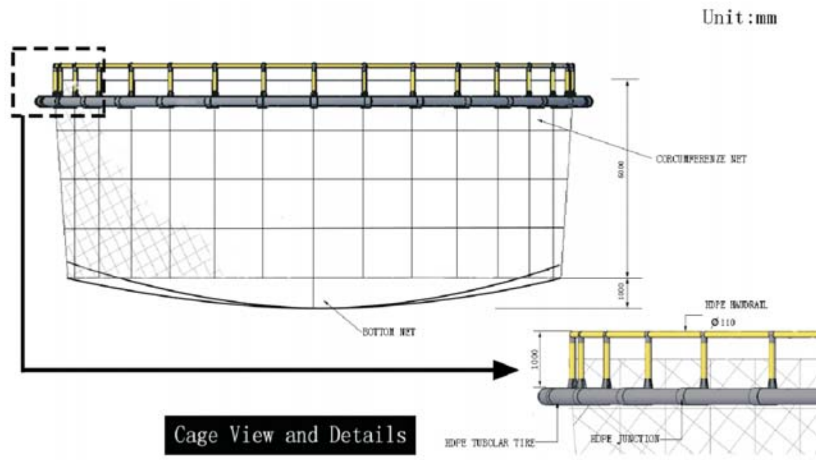
The fingerlings stocked in indoor nursery at around 2 grams will attain an average weight of 45 grams in 6 weeks, and about 70 grams in another 4 weeks of outdoor nursery rearing. The juveniles would reach an average weight of 1.0 kg in 4 months and 2.5 – 3.0 kg in 6- 7 months of grow-out culture in sea cages. The grow-out fishes would reach an average weight of 7.0 kg with a maximum weight of 8.0 kg within the culture period of one year which is almost 100 times the initial weight.

indoor (Nursery Phase 1) followed by 4 weeks outdoor (Nursery Phase 2) before stocking in grow-out cages. The nursery phase 1 can be carried out in FRP tanks of 7 ton capacity with 5 ton filtered sea water. The stocking density has to be kept as 1-2 nos. per litre. The fingerlings have to be fed with formulated diet (assorted size from 400 μ to 1200 μ) thrice daily. The weaning to chopped low-value fishes can be practised during the last week of this phase. The water exchange has to be done 100% daily.

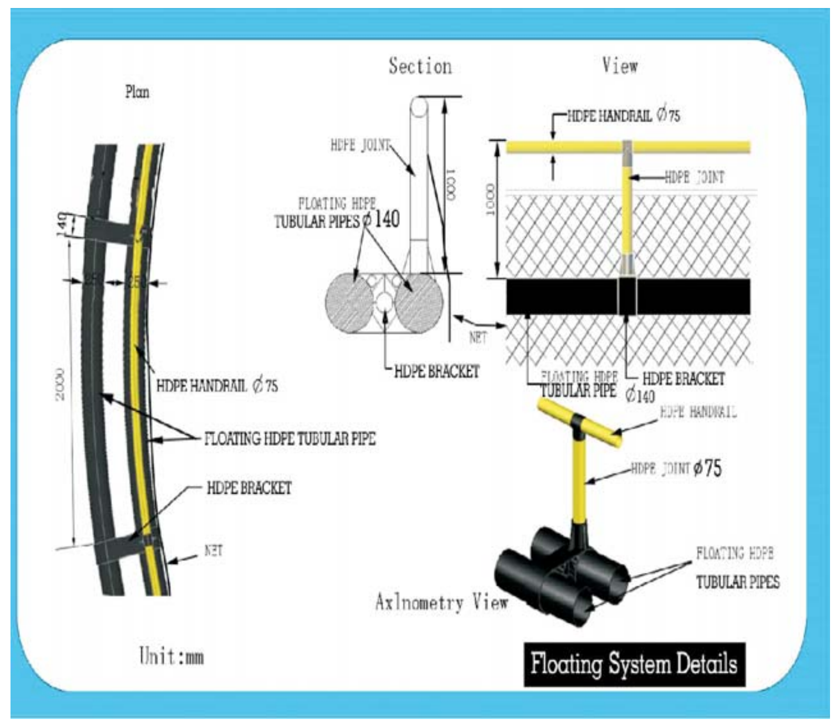
Nursery Phase 2

The nursery phase 2 has to be carried out in specially designed sea cages. These nursery cages should be made of HDPE pipes or GI Pipe (C - Class type) material. The dimension of the square sea cage has to be kept as 4x4 meter with the handrail fixed at one meter height from the base otherwise a circular cage of 6 meter dia can be used. The net cages can be fabricated with HDPE ropes of 2.5 mm thickness. The mesh size of the cage nets shall be 20 mm for inner net cage and 40 mm for outer net cage. The depth of the net cage shall be kept 3 meters from the base. The shape of the net cages has to be maintained with ballast. The buoyancy of the cages can be enabled by tying HDPE drums with the cage frame and has to be moored with two numbers of Galvanized Iron (GI) anchors of 70/100 kg each in opposite directions.

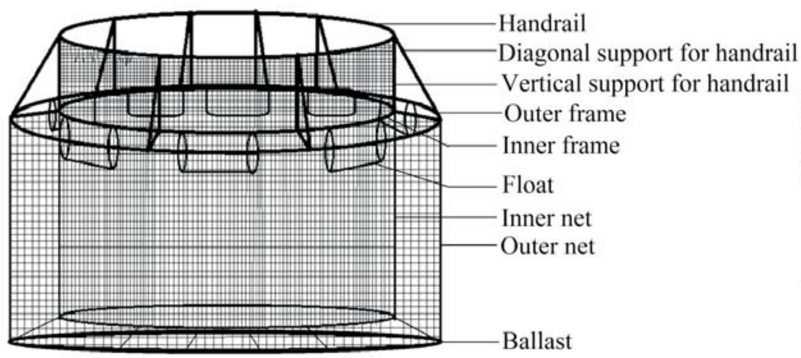
The fingerlings from nursery phase 1 have to be transferred to these floating nursery sea cages. The stocking density (biomass) at this phase can be maintained at 1.8-3.0 kg/m^3. The fingerlings have to be fed @ 5% total biomass of fish with chopped low-value fishes (Sardine, lesser sardine, rainbow sardine, etc.) twice daily. Net cages have to be changed based on the subjective assessment of clogging of the net in order to have sufficient water exchange. Random sampling has to be carried out weekly with the sample size of 30 nos. per cage. This phase can be continued for about 4 weeks.

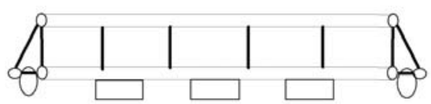


Schematic diagram of a circular cage



Schematic diagram of GI cage





Cross section of GI cage

TECHNICAL SPECIFICATIONS

HDPE Cage frame

1. HDPE Cage inner Diameter – 6m
2. Type – Circular floating cage with 2 floating pipes and hand rail pipe.
3. Floating Pipe – 140mm Outer dia, PE 100 virgin HDPE material, Pipe thickness (10mm - 12mm) and UV resistant.
4. Railing Pipe – 75mm Outer Dia, PE 100 virgin HDPE material, Pipe thickness – (8mm - 10mm), with UV resistant.
5. Bracket – HDPE injection moulded with inner dia – 140mm and UV resistant.
6. Railing Height – 1m from floating pipes

XII. Better Management Practices in cage farming

The better management practices need to be adopted to ensure success in farming and expand the market by offering quality aquaculture products that meet food safety standards. Adoption of BMP's also helps fish farmers to achieve better economic returns. Some of the key factors in BMP includes:-

- Avoiding over-stocking of fish fingerlings
- Monitoring the growth rate and regulating the stocking density in different cages at appropriate time intervals.
- Careful feeding of fishes using to ensure that all the fishes get equal ration of feed.
- Cleaning and regular exchange of cage nets for effective water exchange.
- Proper removal and disposal of dead fishes.
- Usage of approved feed supplements and additives as recommended by the fisheries department officials and CMFRI scientists/technical staff.
- Proper acclimatization of fish fingerlings prior to stocking.
- Regular prophylactic treatment of fishes with disinfectants.
- Periodic monitoring of Dissolved Oxygen level, pH , water temperature, etc..
- Observing the weather conditions, changes in seawater quality, Harmful Algal Blooms etc
- Close observation of fish behaviour while feeding them to assess the health status.

XIII. Cage farming of cobia

Nursery Phase 1

The 4 weeks old cobia fingerlings can be reared for 6 weeks recording keeping are given below for better feed management as well as monthly growth pattern assessment.

Feed Management Register

Name of the Farmer:	
Location of the Cage Farm:	
Date of fish fingerling Stocking:	
Name of the fish and quantity stocked in the cage:	
Source of fish fingerlings:	
Average length and weight of the fish at the time of stocking:	

Date	Quantity of feed used		Total Feed used / day	Remarks
	Morning	Afternoon		
01-01-2018				
02-01-2018				
03-01-2018				
...				
...				
...				
30-01-2018				

Growth Monitoring (Sampling Sheet)

Date of Sampling:		
Sl.No.	Fish Length (in cm)	Fish Weight (in Grams)
1.		
2.		
3.		
4.		
5.		
...		
...		
...		
30.		

7. HDPE cage fitted with stoppers for brackets to hold it in place.
8. 9 Brackets will be used per cage.

Galvanized Iron (GI) cage frame

1. GI Cage inner diameter – 6 meters and outer dia meter 7 meters
2. Quality of the material: Galvanized Iron 'C' class pipe of 4 mm thickness and inner diameter of 40 mm
3. Type – Circular cage with inner and outer frames and hand rail pipe.
4. Railing Height – 1 meter from circular frame base and diagonal support with 1.10 meters
5. Plastic barrels (200 litres capacity) filled with air -8 Nos.
6. Two or more coats of Epoxy painting over one coat of primer on the frame
7. Welding joints have to be coated with fibre material
8. Welding joints in the inner and outer frame need to be given with additional support of 1 ¼ " GI pipe inside the frame

Cage Nets

1. Predator Cage Net – HDPE knotted 280D; 63ply; 80mm kk – 7m dia X 5m deep
2. Bird Net – HDPE knotted 280D; 24ply; 100mmkk – 6m dia
3. Fingerling Net – HDPE knotted 280D; 63ply; 20mmkk – 6m dia X 5 m deep
4. Grow Out Net – HDPE knotted 280D; 63ply; 40mmkk – 6m dia X 5 m deep
5. 10kg concrete block with 10mm dia MS ring(used as

ballasts to retain the circular shape of the cage nets) – 16 nos

6. HDPE/PP binding rope 10mm – As required.

Mooring System for anchoring the cages in sea

1. MS anchors 100kg – 2 nos
2. 5m MS chain 18mm – 2 nos
3. HDPE Anchor rope - 24mm dia – upto 60m
4. Thimble – 2 nos
5. Rope clip – 2 nos
6. D-Shackle 12T – 4 nos
7. Marker Buoy 10L – 2 nos
8. HDPE Marker rope 10mm dia – 2 nos
9. Solar Marker Light – 1 no

Net size according to size of fish for cage culture

Rearing method	Duration of culture (months)	Rope thickness (mm)		Mesh size (mm)		Weight of fish (g)
		Inner net	Outer net	Inner net	Outer net	
Fingerling	0-2	1.5	2.0	20	40	Below 100
Grow-out 1	3-4	2.5	2.5	40	60	100 - 1000
Grow-out 2	5-6	2.5	2.5	40	60	1000-3000
Grow-out 3	6 & above	2.5	2.5	60	80	Above 3000

VII. Feed Management:

Fish feed accounts for a major operational expenditure in cage farming. Proper feed management strategies would help to reduce overall production cost. Optimal use of feed also helps to improve the farming environment and ensure healthy fish stock. Fish feed management includes choosing right feed, correct feeding methods, optimal feeding quantity and cost effectiveness. Feeding of cage farmed fishes with appropriate quantity and quality feeds will prevent the presence of excessive organic matter and pathogens and

- Aeration to maintain dissolved oxygen
- Cleaning of the farm seabed and fallowing or rotation of sites
- Minimising organic pollution from fish wastes and feed wastes

Preventive measures include:

- Preventing the introduction of pathogens
- Maintenance of good water quality
- Avoidance or reduction of environmental stressors
- Adequate nutrition
- Isolation of cultured animals from feral stocks
- Immunization

In the table given in *Annexure1*, common diseases of cobia, their symptoms, diagnosis, therapeutic and prophylactic methods are described.

XI. Record Keeping and Growth Monitoring

Proper maintenance of farm records is an essential part of farm management. Marine fish farmers should maintain records on weather, feeding quantities, water temperature, dissolved oxygen level, length and weight of fishes sampled, fish behavioural changes, diseases and treatments, net exchange details etc. These records provide useful information for analysis of the health status and growth pattern. Sampling of the cage farmed cobia has to be carried out every month to assess the average growth in terms of length and weight of the fishes and to calculate the feed quantity for daily ration. Further, the sampling helps to determine the health status of the fish including external wounds, bacterial infections, parasitic infestations, nutritional deficiencies, anomalies etc. A suitable management solution can thus be identified to enhance culture efficiency. The formats for

The aquaculture industry in India faces various threats including viral, bacterial and parasitic diseases, even at the stage of seeds from hatchery and up to culturing in open water systems. Diseases rarely result from simple contact between fish and the potential pathogen. Environmental problems, such as poor water quality, or other stressors often contribute to the outbreak of diseases.

Predisposing factors

Fish stocks living under stressful conditions become less able to defend against a pathogen and hence will become sick more readily. Fish that are well cared for generally do not become sick even in the presence of a pathogen. The most common error in fish husbandry is overstocking. This leads to problems such as fish to fish aggression, increased fish and feed wastes, ease of disease spread, increased concentration of pathogens and resultant poor water quality. High fish density, stress, and ease of transmission increase susceptibility of the fish population to diseases and parasites. In marine aquaculture, diseases present in wild fish can infect cultured fish and spread rapidly.

Prevention and control of diseases in cultured fishes

Prevention of fish disease is accomplished through good water quality management, nutrition, and sanitation. Farm hygiene is vital to maintaining fish health. It involves routine activities carried out by the farmer to ensure the following:

- Removal of bio-fouling from net/pens
- Water quality testing and correction of poor water quality includes the following:
- Measure dissolved oxygen and water
- Chemistry values e.g. salinity, temperature, pH, ammonia, nitrite and nitrates.
- Measure bacterial counts e.g. *Vibrio* spp. counts of the water

mitigate problems like low dissolved oxygen and bacterial growth. Use of extruded formulated pellet feed instead of trash fish will help to reduce organic matters in water. Feed quantity has to be reduced when the fishes are under stress or during rough weather or during low water temperature. Feeding has to be done slowly to give enough opportunity to all the fishes to feed. Marine fishes require high level of protein and fat for their metabolic activities and growth. The nutritional requirements vary with different fish species, sizes, growth stages and feeding habits. Carnivorous fishes like cobia, silver pompano and Asian seabass require a higher protein and fat than omnivorous and herbivorous marine and freshwater fish species.

Feeding Chart for Cobia (in case of low-value fish as feed)

Sl. No.	Average body weight of the fish	Feeding rate per day in terms of per cent total biomass
1.	Below 500 g	10 %
2.	500 to 2000 g	7 %
3.	2000 to 5000 g	5 %
4.	Above 5000 g	3 %

Nutritional Requirement of Cobia (in case of extruded pellet feed)

Weight of the fish	Crude Protein (%)	Crude fat (%)	Pellet size (mm)
1.	48	12	2 or 3 or 5
2.	45	10	10 or 15 or 25
3.	40	10	50

VIII. Bio-fouling and Exchange of Cage nets

Cage farming activities enrich the sea with nutrients and coupled with warm water temperature, forms an ideal habitat for fouling organisms like barnacles, mussels, sea weeds and algae to grow on the net and cage surfaces. Proliferating fouling organisms not only consume a great deal of dissolved oxygen, but also block the meshes of nets and impede effective replenishment of dissolved oxygen in sea water inside the cage area. Fouling organisms may also add weight to the cage nets and cause damage to nets and sinking of the cages. To avoid this situation, cage nets have to be cleaned regularly to prevent the attachment of fouling organisms. Inspection of the cage nets regularly and repairing of torn or damaged parts and exchange of nets having more fouling needs to be undertaken. Nets having high level of fouling needs to be dried under sunlight for prolonged exposure and all the barnacles and algal attachments on the nets need to be cleaned. Repairing of any damage found in the cage unit including mooring system would help to maintain the buoyancy as well as healthy cage frame.

IX. Monitoring of water quality

Water quality is the critical factor which determines the growth and survival of the fishes reared in the cages. If the water quality parameters fall outside the optimal range,it would create stress to the fishes leading to weakness and infection by opportunistic pathogens. Monitoring of water quality helps to detect disease at an early stage and reveal the cause of stress/mortality. Normal symptoms like low intake of feed, sluggish movement of fish, abnormal swimming behaviour etc., can be noticed when the fishes are under stress or infected with pathogens. Routine examination of the body surface, fins and gills for the presence of parasites or disease symptoms would help to take therapeutic measures at the initial stages of infection. Basic water quality parameters such as level of dissolved oxygen, pH, salinity, water temperature and turbidity can be measured at specific time intervals daily. These parameters vary according to the seasons in the East and West coast of India. Unless in special conditions (monsoon/winter), water quality parameters of cage farming areas should generally remain within the following ranges:

Sl. No.	Water Quality Parameter	Range
1.	Dissolved Oxygen	5 – 8 mg/L
2.	Water temperature	28 - 33
3.	pH	7.9 – 8.3
4.	Salinity	25 – 34 ppt
5.	Transparency	40 cm and above

X. Prevention and treatment of fish diseases

Successful fish health management begins with prevention of disease rather than treatment. Fish diseases affect the survival and growth of fish reared in the cages. Outbreak of diseases invariably lead to lower harvest quantity and higher production cost. Farmers also often suffer huge economic losses due to fish disease outbreak. Hence, it is essential to take precautionary steps to prevent the outbreak of fish diseases and to strengthen the natural immune resistance of the fishes. Regular observation of fish is an effective way to identify abnormal behaviour, disease causes and appropriate treatments. Pathogens like bacteria, viruses, fungi and parasites are existing in the natural environment and healthy fish possess adequate resistance against them. When the pathogen level in the water increases sharply due to various factors and if the natural immune resistance of the fish is weak, fish will become vulnerable to pathogenic infection and diseases. To prevent and control fish diseases, maintaining a good farming environment and use of hygienic and nutritious fish feed to boost resistance of the fish is essential.

A brief note on the common diseases of cultured cobia, their prevention and control, based on our own experience, is given below for ready reference. The photographs on symptoms of certain diseases will help in early diagnosis and control of mass mortality during culture.